

HYD 279

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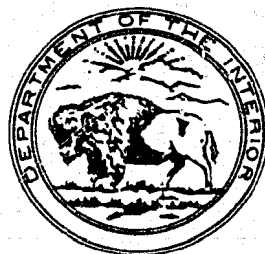
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

BUREAU OF RECLAMATION
HYDRAULIC LABORATORY
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HYDRAULIC MODEL STUDIES OF MEDICINE
CREEK DAM SPILLWAY--FRENCHMAN-
CAMBRIDGE UNIT--MISSOURI RIVER
BASIN PROJECT, NEBRASKA

Hydraulic Laboratory Report No. Hyd.-279

RESEARCH AND GEOLOGY DIVISION



BRANCH OF DESIGN AND CONSTRUCTION
DENVER, COLORADO

JULY 6, 1950

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UNITED STATES
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Branch of Design and Construction
Research and Geology Division
Denver, Colorado
July 6, 1950

Laboratory Report No. Hyd-279
Hydraulic Laboratory
Compiled by: J. C. Schuster
Reviewed by: J. W. Ball and
W. C. Case

Subject: Hydraulic model studies of Medicine Creek Dam spillway--
Frenchman-Cambridge Unit--Missouri River Basin Project,
Nebraska.

PURPOSE OF STUDY

The hydraulic model studies discussed in this report were made to determine the capacity and to investigate the flow conditions in the approach channel, over the crest, in the chute, and in the stilling pool of the Medicine Creek Dam spillway to assure its satisfactory performance.

CONCLUSIONS

1. The use of a vertical approach wing wall, constructed of circular arcs with radii varying from 192 feet at the crest to 20 feet at the upstream end, on the right-hand side of the approach channel of the Medicine Creek Dam spillway will provide satisfactory flow conditions in the channel and at the crest for floods up to and including the design capacity of 98,000 cubic feet per second (Figures 8 and 9H).

2. The best flow conditions at the crest were obtained when a vertical approach wing wall with its top above the reservoir surface and having a plan section of an elliptical curve (Figure 9F) was used upstream on the right-hand side of the spillway. It is believed that the same type of wall would operate equally as well on other structures where the dam forms one side of the spillway and the approach flow is across and parallel to the face of the dam.

3. Pressures on the crests of the recommended spillway will be above atmospheric for all flows.

RECOMMENDATIONS

1. Use the right approach wing wall designated Design H (Figure 9) which is a vertical wall having a plan section of circular arcs.

ACKNOWLEDGMENT

The design of the hydraulic features of the Medicine Creek Dam spillway were evolved through the cooperation of engineers of the Dams Division and the Hydraulic Laboratory.

INTRODUCTION

Description of Prototype Structure

Medicine Creek Dam and Reservoir are located approximately 10 miles north of Cambridge, Nebraska, on Medicine Creek (Figure 1). This reservoir is linked with Enders Reservoir for flood control and irrigation storage. The dam is a compacted earth structure having a length of 4,000 feet, a thickness at the base of approximately 650 feet, and a height of 102 feet above the stream bed.

The flow from the reservoir is passed over a spillway at the left abutment of the dam or through an outlet works located approximately 1,600 feet to the right of the spillway and passing through the dam. Normal discharges of the creek are handled by the outlet works or by a 13-foot wide normal-flow crest at elevation 2366.1 in the center of the spillway, while flood discharges are released over a 200-foot wide flood-flow crest at elevation 2386.20 (Figure 8). Spillway discharges will flow into a concrete-lined stilling basin having a constant width of 262 feet and designed for a maximum of 98,000 cfs. Water is supplied to the outlet works by a tunnel and 44-inch pipe from the reservoir. A 3-foot 3-inch by 3-foot 3-inch high-pressure slide gate controls the discharge from the outlet and releases it into the outlet stilling basin. A report of the hydraulic studies for the design of the outlet works will be published at a later date.

Two Types of Spillway Considered

Two crest designs for controlling the spillway discharge were studied, one at elevation 2362.2 controlled by four 50- by 24-foot radial gates, and the other 24 feet higher and uncontrolled. Both designs contained a 13-foot section of uncontrolled crest at elevation 2366.1 on the center line of the spillway.

INVESTIGATION OF ORIGINAL SPILLWAY USING RADIAL GATES

Description of Gate-Controlled Spillway

Four float-controlled 50- by 24-foot radial gates were included in the original design of Medicine Creek spillway. A maximum discharge of 139,000 second-feet was to be passed by these gates and the short length of uncontrolled crest. The gate-controlled flood-flow crest at elevation 2362.2 had a net length of 200 feet, while the uncontrolled

section 3.9 feet higher at elevation 2366.1, designed to pass the normal flow of the creek, had a length of 13 feet. All water discharged by the spillway flows into a 278-foot-wide concrete-lined rectangular stilling basin, which discharges 500 second-feet per foot of width at the maximum flow. Chute blocks, 6 feet 9 inches high by 6 feet wide, were placed at the upstream end of the stilling basin and a dentated sill 8 feet high was used at the downstream end. The training walls of the stilling basin were designed with a height of 55 feet to provide 8 feet of freeboard above the normal tail water elevation for the maximum design discharge.

Description of Spillway Model

The hydraulic model of the gate-controlled spillway (Figure 2) was built to a scale of 1:60. The model consisted of a portion of the reservoir, the upstream approach channel, all of the spillway, including the stilling basin, and a section of the channel downstream. Topography upstream of the spillway was constructed of concrete and the topography downstream was formed in sand. The spillway crest, chute, and stilling basin apron were formed of concrete using metal templates as guides. The radial gates of the original design were made of metal and the piers of wood. Water for the model was supplied by a 12-inch centrifugal pump and measured by Venturi meters. The flow approaching the crest was uniformly distributed by discharging the water behind and passing it through a rock baffle. Point gages, with vernier graduations to thousandths of a foot, were used to measure reservoir and tail water elevations. Piezometers were located in both the flood-flow and normal-flow crest sections for determining water pressures during operation.

Initial Tests

When the model of this design was placed in operation, a disturbance caused by the right approach wing wall resulted in an unequal flow distribution at the crest. Also wave action in the stilling basin showed evidence of overtopping the training walls. The original approach wing wall for the right side of the spillway was studied only qualitatively by observing its effect upon the flow of the approach channel. In determining the effectiveness of the stilling basin the location and appearance of the hydraulic jump and the water surface profile with respect to the training walls were studied.

Stilling Basin Studies

There was danger that the waves in the stilling pool would top the training walls and remove the backfill. However, some economy would be realized if the height of stilling basin training walls could be reduced and tests were conducted to see if this could be done. Observations and measurements of the waves were made by painting the walls with a paint which retained evidence of being wetted and by the use of a point gage. The wetted surface of the training walls, as shown in Figure 3, was photographed after 1 minute's operation. After 10 minutes' operation the walls were completely wetted throughout the full length of the stilling

basin. Some water splashed to the top of the wall in the downstream end of the basin but in such small quantities as not to endanger the fill behind the wall. The results of this study (Figure 4A and B) showed that the wall was of sufficient height but could not be lowered.

No erosion tests were made concerning the downstream channel because the design called for riprap below the stilling basin and operation of the stilling basin was satisfactory. To determine how a lowering of the tail water by retrogression of the downstream channel would affect the stilling basin action, a test was made with the tail water lowered various amounts. This test showed that the jump moved to the center of the basin with a tail water depth 13.2 feet below the maximum (elevation 2332.0) for a discharge of 139,000 cubic feet per second.

Flow in Spillway Chute

Water-surface profiles for both the left and right side of the spillway are shown in Figures 4A and B. The difference in the profiles for the sections upstream of the crest was the result of the surface depression in the eddy area at the upstream end of the wing wall on the right side. After the water passes the crest, the depth along the training wall is approximately the same for both sides. In Figure 4C the maximum steady water-surface profile taken transversely across the spillway at the downstream end of the piers is shown. The flow of water from the crest to the stilling basin was uniformly distributed across the spillway chute with the exception of the large fins downstream from the piers caused by the impingement of the flow from adjacent crest sections. The flow pattern in the spillway chute was essentially the same for both 139,000 and 75,000 second-feet (Figure 5).

Wing Wall A—Vertical Wall, 30-Foot Upstream Radius

Water flowing parallel to the dam and at right angles to the spillway center line, resulted in an area of eddying and a surface depression along the right approach wing wall (Design A, Figure 9A). At the maximum discharge of 139,000 second-feet, the disturbance affected the flow on the right side for approximately one-fourth the width of the approach channel (Figure 6). Even at a flow of 75,000 second-feet, the surface depression was appreciable as shown in Figure 6B and this was considered objectionable.

Approach Wing Wall on Left Side

The approach wing wall on the left side of the spillway crest was entirely satisfactory.

Spillway Capacity

Discharge curves were obtained for both crests operating simultaneously and for the normal-flow crest alone as shown in Figure 7.

These curves are for the spillway with right approach Wing Wall A (Figure 9). The capacity for the normal-flow crest with the reservoir at elevation 2386.2 was 3,960 cfs and for the total crest with reservoir elevation 2394.8, 139,000 cfs.

INVESTIGATION OF UNCONTROLLED SPILLWAY

Description of Uncontrolled Spillway

Medicine Creek Dam spillway was first designed to control the flood flow through the reservoir by radial gates. The design of the spillway crest was later changed by the designers to eliminate the radial gates. In this design, the flood-flow and normal-flow crests were expected to discharge a maximum flood of 98,000 second-feet. The 200-foot long crest at elevation 2386.2 was 24 feet higher than the original design or at the same elevation as the top of the fully closed radial gates in the previous design. The 13-foot crest section was maintained at elevation 2366.1.

No tests were planned for the chute and stilling basin in the uncontrolled crest design (Figure 8) for the changes from the original design were of a nature that would aid in the stilling action. The original stilling basin design discharged 500 cubic feet per second per foot of width while the design with the uncontrolled crest discharged 373 cubic feet per second per foot. The width of the basin was changed from 278 feet to 262 feet, while the length of the basin was left at 165 feet. Chute and sill blocks were kept the same dimensionally with the exception of the end blocks and the number of blocks. The original design contained twenty-one 6-foot-wide blocks with one 8-foot-wide block at each training wall, while the uncontrolled crest design contained twenty 6-foot blocks with one 7-foot-wide block at each training wall. The floor of the basin was raised from elevation 2285 to 2287. The top of the training wall was lowered from elevation 2340 to elevation 2334 giving a stilling basin depth of 47 feet compared to 55 feet for the original design. The maximum tail water elevation for a discharge of 98,000 cubic feet per second was 2328, which allowed a 6-foot freeboard.

Study of the Right Approach Wing Wall

When the 1:60 model of the uncontrolled spillway crest was placed in operation, the right approach wing wall indicated the need of further study. The approach channel flow on the right side was disturbed by the conditions at the right wing wall and the disturbance carried across the crest into the spillway chute.

There was no apparent improvement in the approach flow conditions at the right side, although the approach channel was increased in depth by 24 feet from the original design and the maximum discharge was decreased from 139,000 cubic feet per second to 98,000 cubic feet per second. The position of the spillway with respect to the dam was the

same in both designs, thus, part of the water from the reservoir side still flowed at right angles to the spillway center line with the same relatively shallow depth at the end of the wing wall. The use of a wall that extended farther upstream into the reservoir where velocities were lower was prevented by the excessive depth to proper foundation material and the cost of the structure.

Seven additional designs of the right approach wing wall were studied.

Wing Wall B---Vertical Wall---525-Foot Radius

A vertical wall constructed on a radius of 525 feet was extended about 170 feet upstream into the reservoir, Design B, Figure 9B. The top of the wall was horizontal at elevation 2410 for 60 feet upstream and then sloped to elevation 2355 for the remaining 110 feet, both measurements being perpendicular to the upstream face of the crest.

The flow disturbance caused by this wall covered approximately one-half the width of the approach channel. Within this region of disturbance, there was an upstream velocity along the channel side of the wall and an eddy near the upstream end of the wall. This design was abandoned for three reasons: (1) nonuniform change in velocity along the wing wall, (2) possible erosion of the channel, and (3) objectionable turbulence of the water surface on the right side of the approach channel.

During the study of Wing Wall Design B, it was found that the elevation of the approach channel could be increased by 5 feet. This change raised the approach channel floor elevation from 2355 to 2360, resulting in no apparent difference in the approach flow conditions or in the capacity of the spillway.

Wing Wall C---Vertical Wall, 45° with Respect to Spillway Axis

The appearance of the flow around and past Wing Wall B pointed out that the change in direction of flow at the upstream end of the right wall was still too abrupt.

To give a more uniform change in the velocity of the water approaching the spillway crest, Wing Wall C, Figure 9C was constructed. The wall was vertical. It started at the crest on a 45° arc of 60-foot radius and continued upstream for approximately 120 feet on a tangent to the arc and at an angle of 45° with the axis of the crest. The top of the wall was horizontal at elevation 2410 except for the last 50 feet which was sloped to elevation 2395. The surface depression occurred at the upstream end of the wall as shown in Figure 10. In addition, there was a flow disturbance where the water passed over the sloped upstream end of the wall. An eddy formed near the upstream end of the wall and extended out into the approach channel. This design did not appear satisfactory although it proved to be slightly better than A or B at lower discharges. The change in velocity in the approach channel still was not uniform.

Wing Wall D—Vertical Wall, 45° with Respect to Spillway Axis, 15-Foot Upstream Radius

Wing Wall D, Figure 9D, was constructed at the same angle with respect to the upstream face of the spillway as C, but a 135°, 15-foot-radius curve was added to the upstream end. The action of the water around this wall is shown in Figure 11. Some of the disturbance at the upstream end was eliminated, but a turbulent condition existed along the straight portion of the wall. This design was abandoned when it was found that it extended 15 feet too far upstream where the depth to satisfactory foundation material was excessive.

Wing Wall E—Warped Surface

Wing Wall E, Figure 9E, was then proposed. It was a warped surface extending from vertical at the crest on a 50-foot radius curve to the 2-1/2:1 slope at the upstream face of the dam. In the field this wing wall would be constructed with a vertical retaining section on the channel side and the curved surface which extended to the face of the dam would be covered with hand-placed riprap. The approach was considered entirely unsatisfactory except at low discharges because of excessive turbulence which extended from the beginning of the 50-foot radius around the wall to the crest. As shown in Figure 12, the turbulence carried out into the channel affecting the flow in the right one-half of the approach channel.

Wing Wall F—Vertical Wall on Elliptical Curve, 25-Foot Upstream Radius

Upon completion of the study of Wing Wall E, a modification of Wing Wall D seemed to be the logical solution of this problem. A 140-foot-radius arc, tangent to the training wall at the upstream face of the flood-flow crest, was extended approximately 107 feet upstream. A 135°, 25-foot-radius arc, tangent to the 140-foot-radius arc, extended the wall back to intersect with the face of the dam. A small concrete retaining wall was placed at the outer end of the wing wall with its base at elevation 2360 and its top sloping from elevation 2380 at the wing wall to elevation 2360 at its outer end. Its purpose was to retain the upstream face of the dam where it intersected the wing wall. This wing wall design proved to be the most satisfactory tested thus far, but there was still an excess of turbulence at the upstream end which extended to about the middle of the wall and approximately 10 feet into the channel. To eliminate as much of this disturbance as possible, a false wall was placed in the eddy area along the original curve. It was found that the resulting wing wall, Figure 9F, had coordinates approximating the equation of an ellipse. Figure 13 shows the flow in the channel for this design.

Wing Wall G—Vertical Wall of Circular Arcs, 20-Foot Upstream Radius

Wing Wall Design F was altered when it was found that foundation conditions were not satisfactory. The resulting Wing Wall G

is shown in Figure 9G. This wall was formed by the use of circular arcs which approximated the elliptical curve of Wall F. A 20-foot radius instead of a 25-foot-radius curve at the upstream end reduced the distance from dam to the upstream extremity of the wall by approximately 5 feet. The upstream end of the wall sloped from elevation 2410 to elevation 2390 in approximately 50 feet. The space behind the wing wall was filled to elevation 2407, leaving the top 3 feet of the wall extending above the fill to form a parapet. The small wall for retaining the upstream face of the dam was similar to that used with Wing Wall Design F.

Surface disturbance along the channel side of the wall remained essentially the same as that found for Wing Wall F. An increased disturbance resulted from the water pouring over the top of the sloped portion of the wall at the upstream end, as shown in Figure 14. If this design were used, it would be desirable to riprap the 2:1 slope behind the end of the wall to prevent erosion in this area.

Wing Wall H--Recommended Design--Vertical Wall of Circular Arcs, 20-Foot Upstream Radius

A final change was made in the wing wall (Design H, Figure 9H) when the top of the 20-foot-radius section of wall at the upstream end was maintained at elevation 2410. This revision eliminated the sloped portion of the wall and thus prevented the overflow that occurred in Design G. Good flow conditions were obtained in the channel (Figure 15) and the design was recommended for Medicine Creek spillway.

Flow Conditions in the Approach Channel--Recommended Design

With the completion of the studies on Wing Wall Design H, the approach channel and crests shown in Figures 15A and 16A were considered to be hydraulically acceptable. Further studies were made to record operational characteristics, such as water-surface profile, pressures on the crests, and flow capacity of the spillway.

Figure 17A shows the water-surface profile on a developed length of Wing Wall H. The slight surface depression noted at the upstream end was not considered objectionable.

Figure 17B shows the water-surface profile for the left side of the spillway. The approach on the left side was the same as the original design which was considered satisfactory. There was very little turbulence with this wall because the water approached parallel to the spillway center line with a uniform increase in velocity.

Flow Conditions at the Crest--Recommended Design

Transverse surface profiles were taken at two stations across the spillway crest as shown in Figure 17C. The first corresponding to the end of the piers or Station A, the second, at the point of tangency of the lower part of the crest and spillway chute, or Station B. The

surface profile at A, for the water flowing between the piers, varied approximately 4 feet from the highest point in water surface to the lowest. The contractions at the leading edges of the piers accounted for some of this variation while the approach conditions caused slight rises in the water surface at the left and right ends of the spillway crest. A vortex-like swirling disturbance occurred on the surface at a point coinciding with the intersection of the upstream face of the spillway at each training wall for all wing wall designs. That on the left was slight, while that on the right was larger but not objectionable. This disturbance passed over the crest and down into the chute, the effect being shown in the raised water surface at each end of the crest (Figures 16B and 17). The cause of this action was believed to be the result of the complex currents at the intersections of the walls with the crest; and the disturbance was eliminated when gravel fillets were placed in the corners made by the approach floor, the training wall and the spillway face. Observations of the pressure conditions on both the flood- and normal-flow crests showed that the pressures were positive for all discharges.

Water-Surface Profile on Piers

Other water-surface profiles were taken on each side of the four piers, Figure 18. These profiles indicate good flow distribution at the crest and no objectionable angularity in the approaching flow.

Flow Conditions Below Crest Piers--Recommended Design

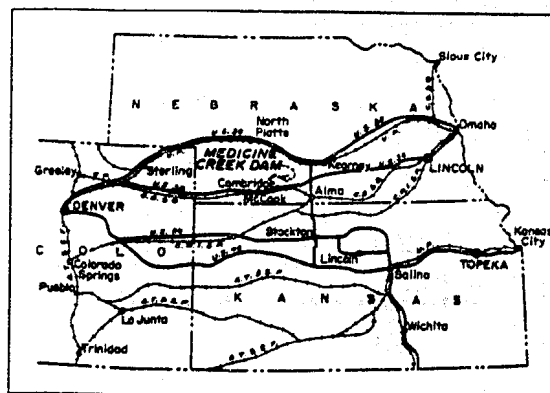
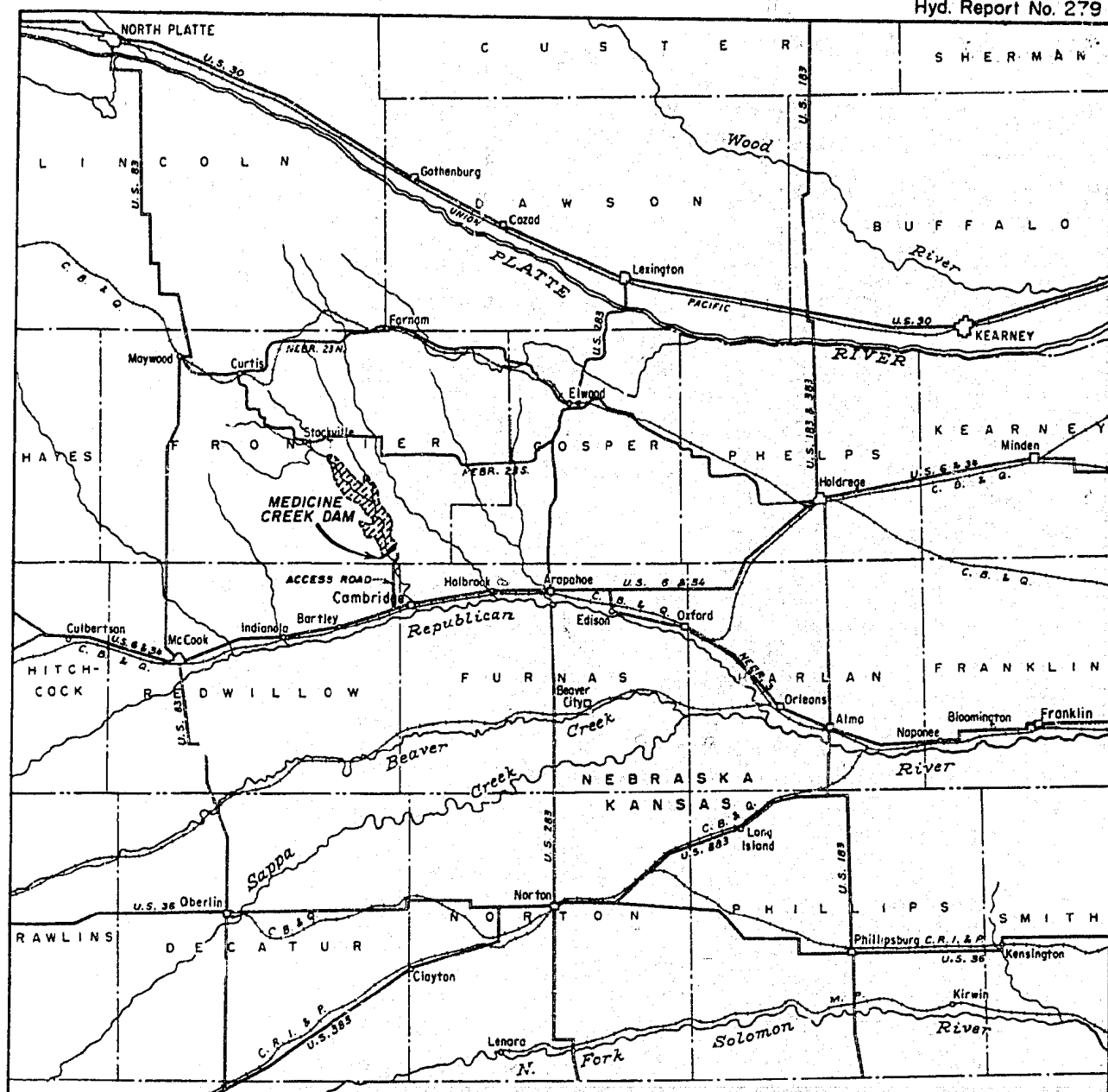
At Station B, the surface profile reflects the interference as water from adjacent crest sections flows together behind the piers. This interference is shown in the form of small peaks in the water surface downstream of Piers 1 and 4 (Figures 16B and 17C). Tests on other similar structures indicate that these peaks could be reduced by streamlining the downstream end of the crest piers so no tests were made for the Medicine Creek spillway. From the base of these peaks toward the center of the spillway, the depth of the water increased to a maximum of 14 feet at the center as a result of the spreading action of the water emerging from the low normal-flow crest section.

Capacity of Recommended Design

The discharge capacity curves of Figure 19 are for the recommended spillway design shown in Figure 8. The capacity was the same as that obtained for the same crest with Wing Wall Designs F and G.

The capacity of the normal-flow crest section with the reservoir at elevation 2386.2 was 3,770 cfs or slightly less than for the original design. This difference was attributed to the changing of the upstream face of the crest from vertical to approximately a 1:1 slope to eliminate the negative pressures found on the original design. The capacity of the spillway with the reservoir at elevation 2408.9 was 99,700 cfs.

FIGURE 1
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KEY MAP

0 10 20
SCALE OF MILES

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI BASIN PROJECT
FRENCHMAN-CAMBRIDGE UNIT - NEBRASKA
MEDICINE CREEK DAM
LOCATION MAP

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DENVER, COLORADO, SEP. 16, 1947

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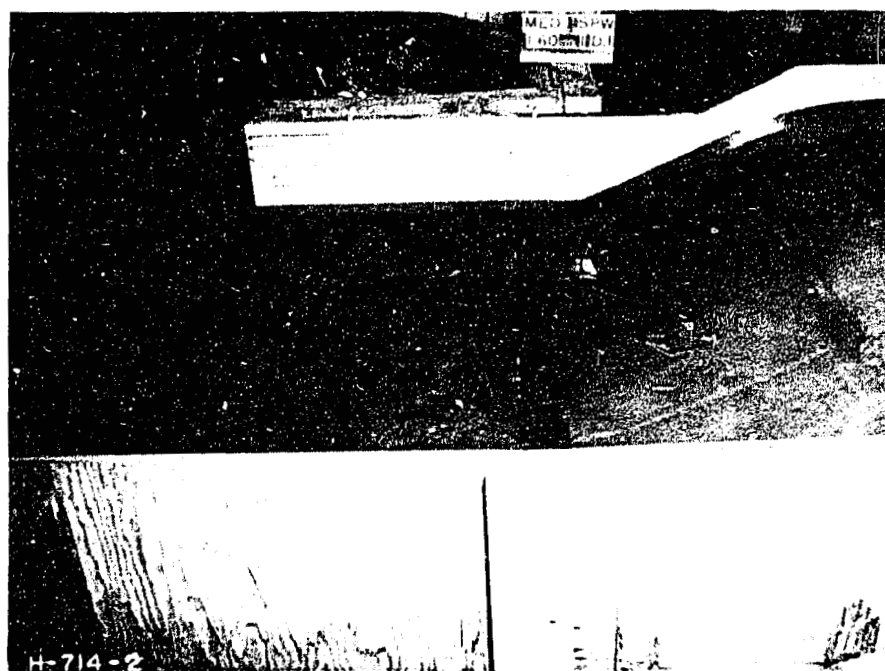


A. Approach Channel Original Design
Discharge 0 second-feet

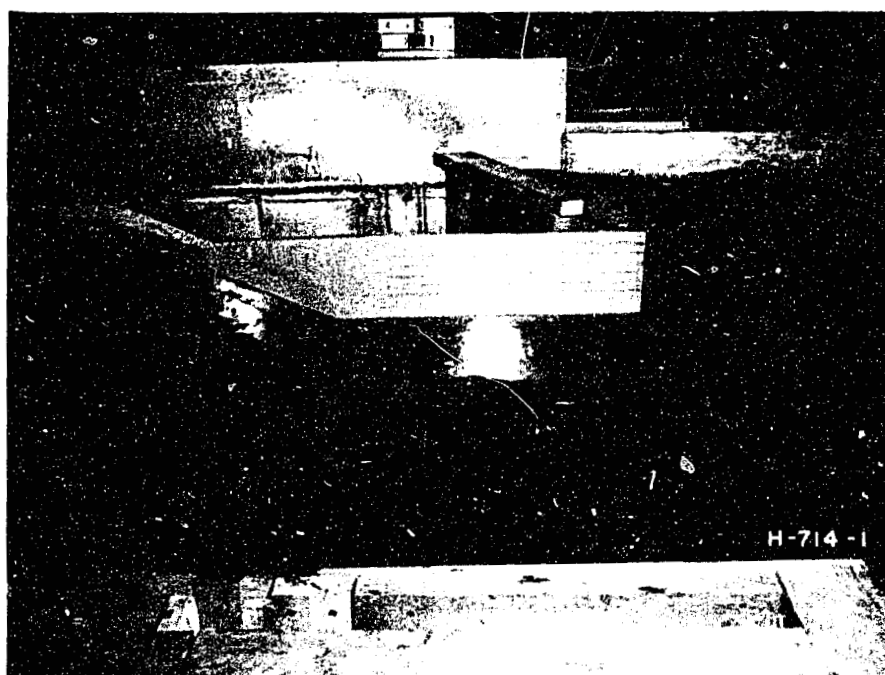


B. Spillway Original Design
Discharge 0 second-feet

1:60 MODEL OF ORIGINAL DESIGN

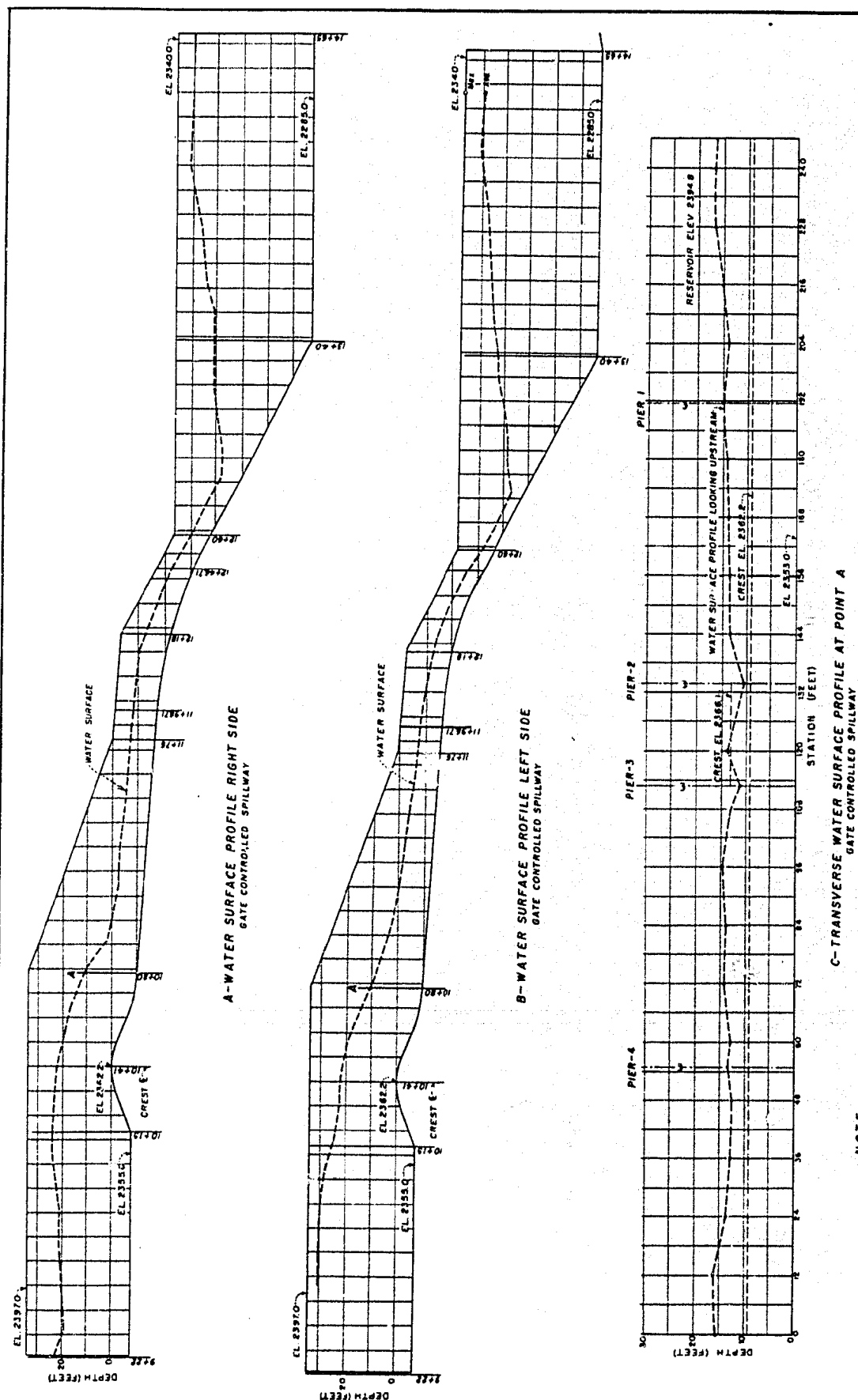


A. Wave Height-Right Training Wall
1 minute operation at discharge 139,000 second-feet

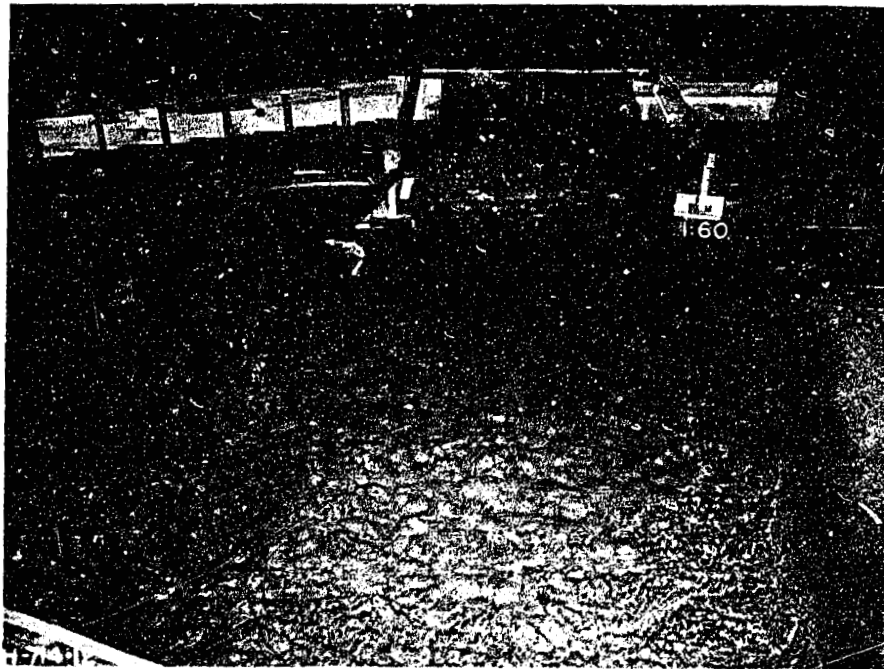


B. Wave Height-Left Training Wall
1 minute operation at discharge 139,000 second-feet

STILLING BASIN WAVE HEIGHT



MEDICINE CREEK DAM SPILLWAY
1.80 MODEL



A. Spillway Original Design
Discharge 139,000 second-feet

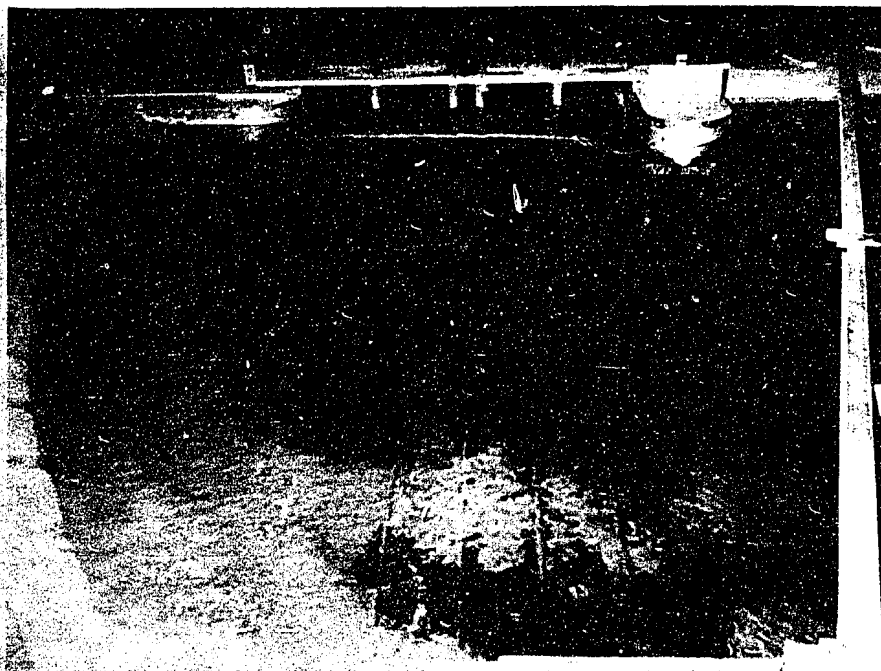


B. Spillway Original Design
Discharge 75,000 second-feet

SPILLWAY-DISCHARGE OF 139,000 AND 75,000 CFS



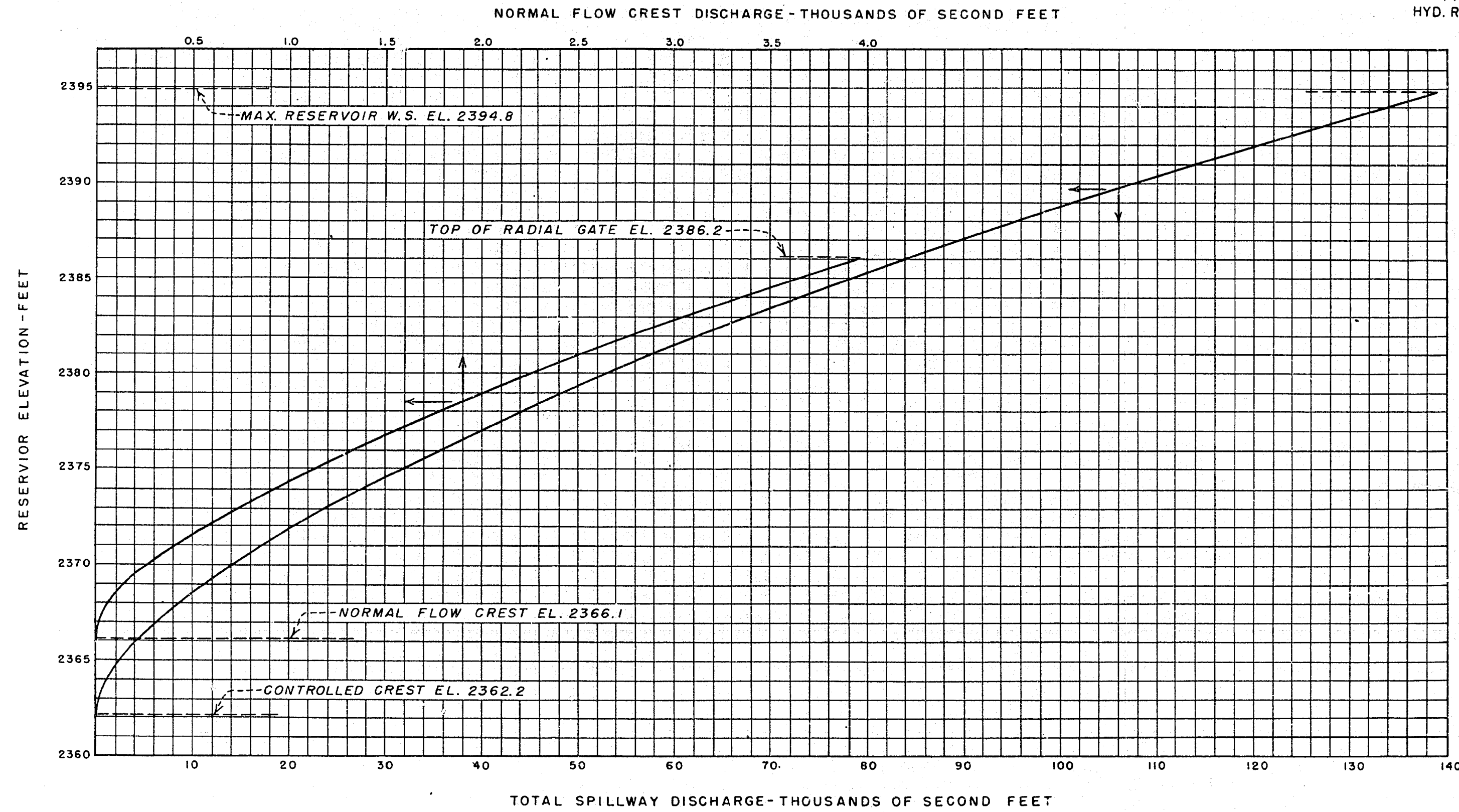
A. Approach Channel Original Design
Discharge 139,000 second-feet



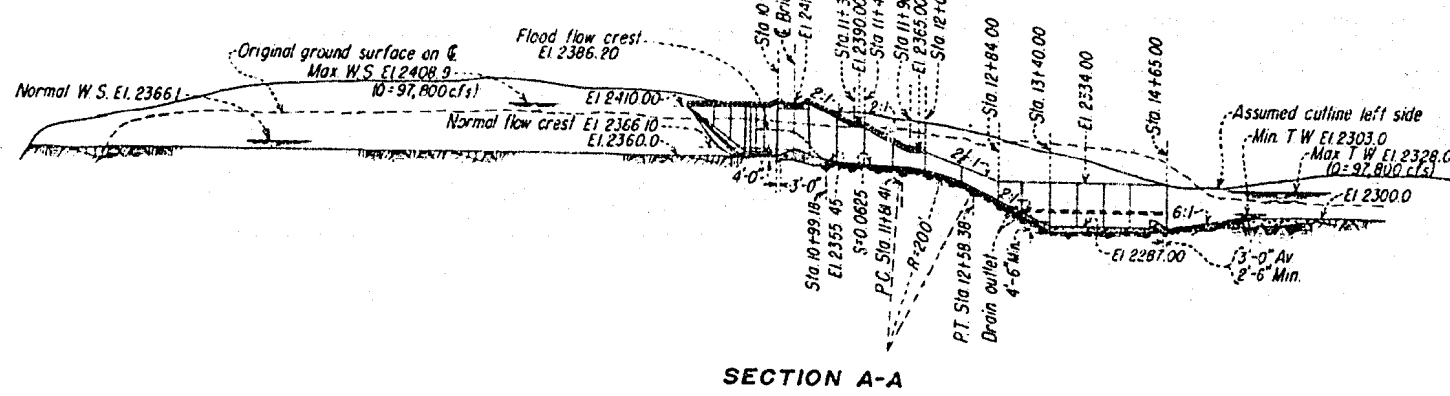
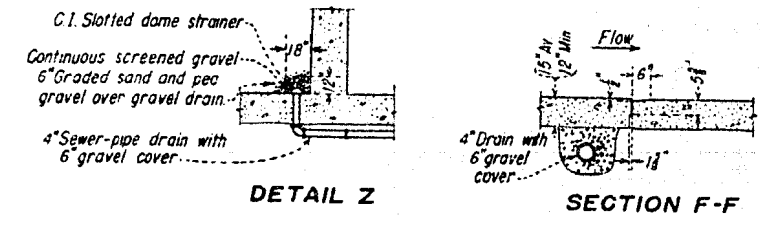
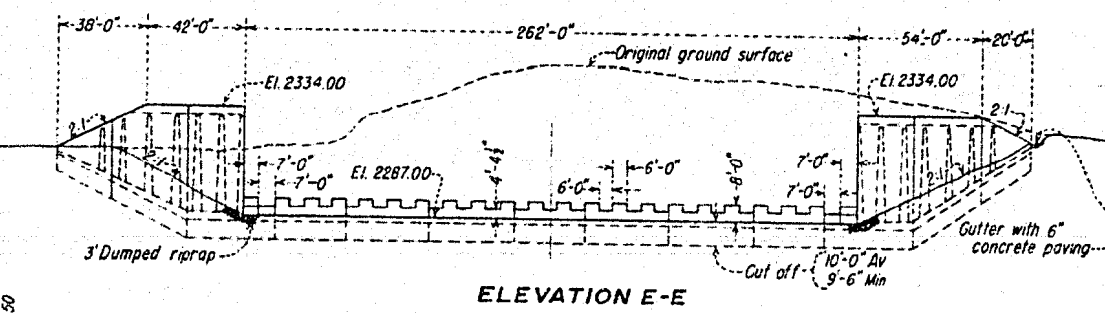
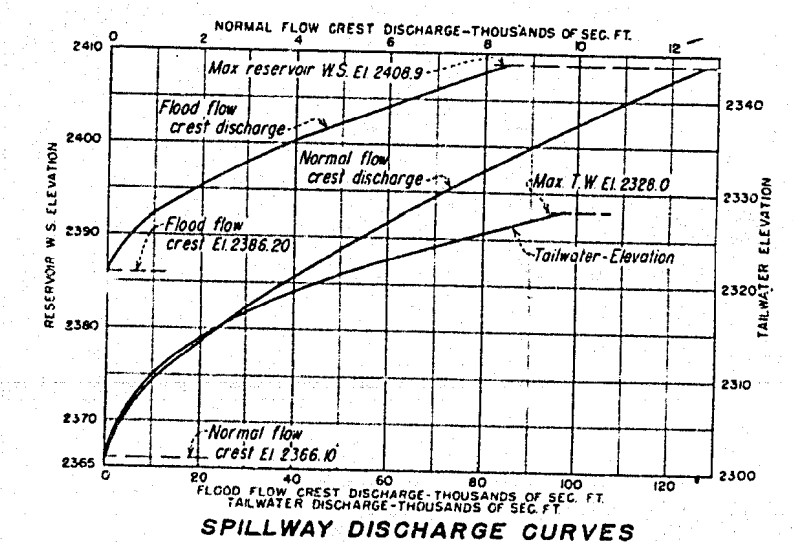
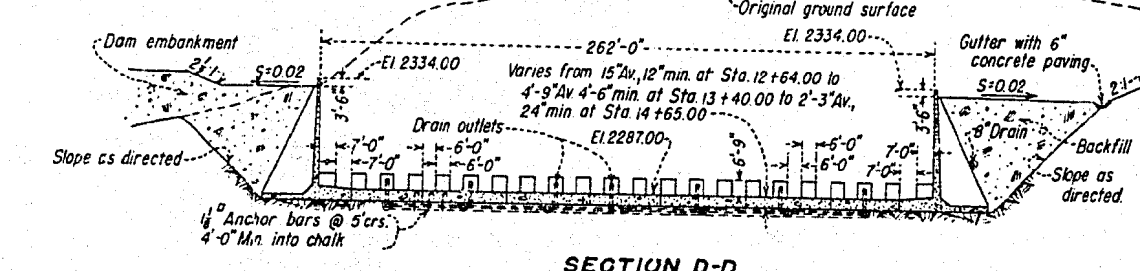
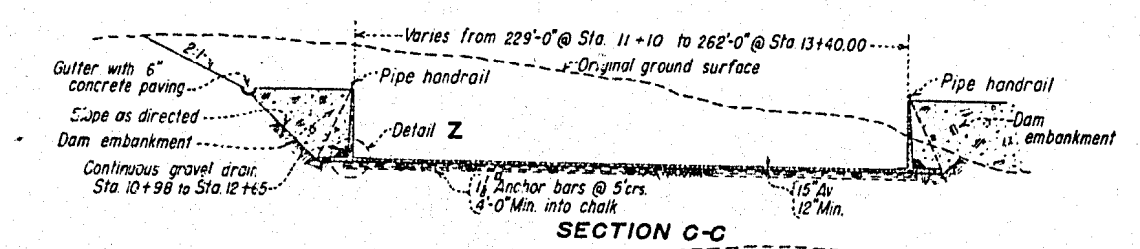
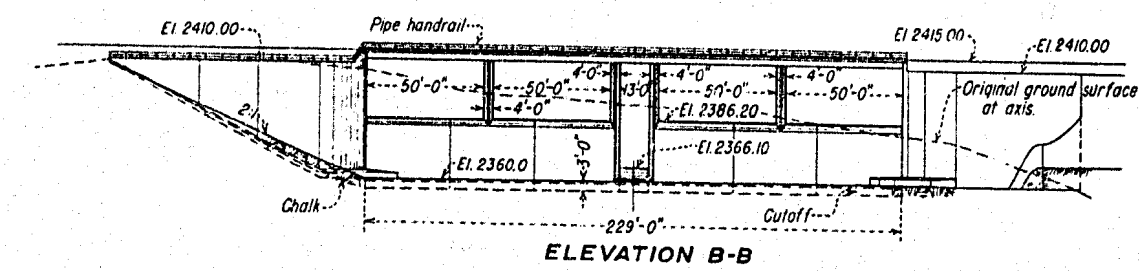
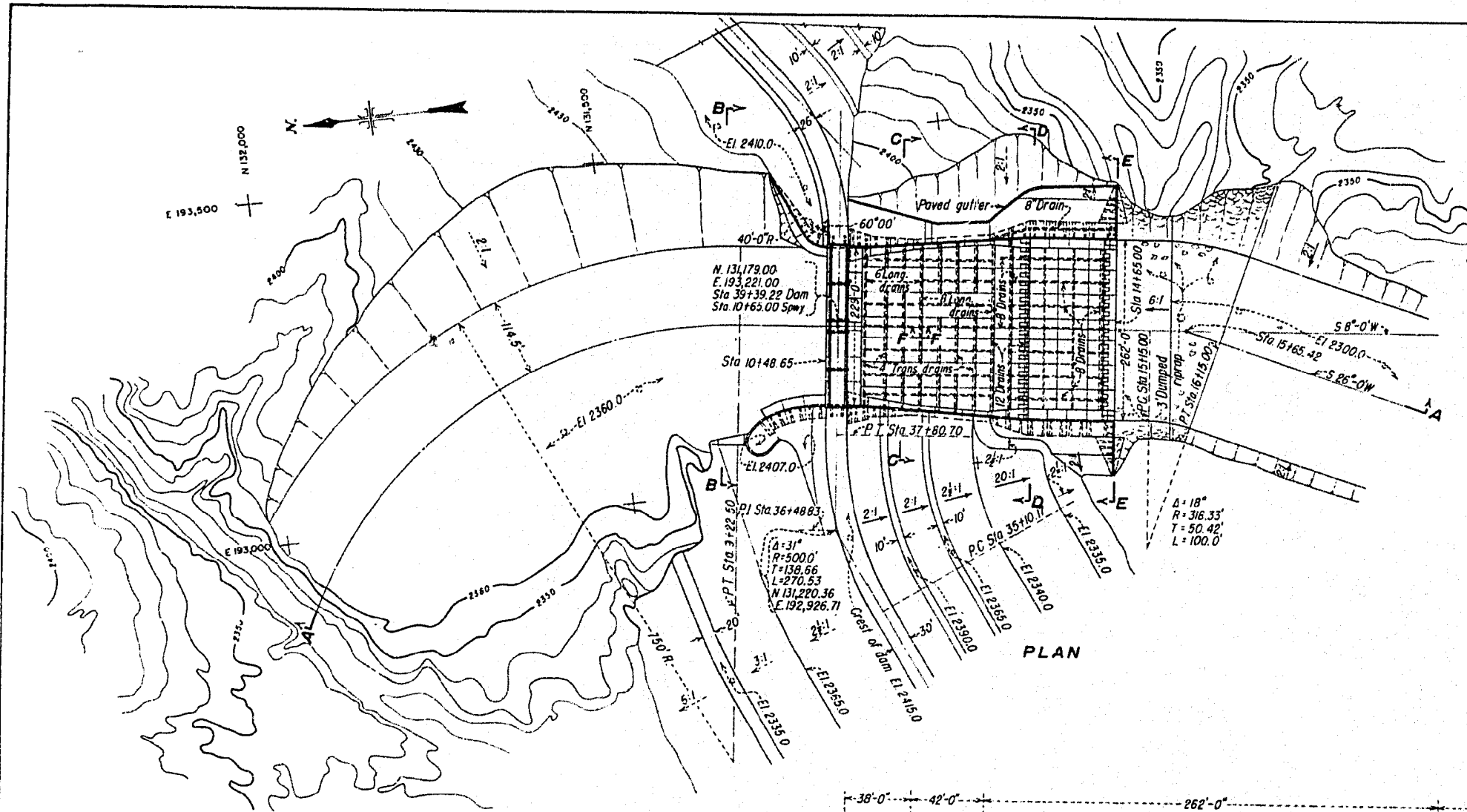
B. Approach Channel Original Design
Discharge 75,000 second-feet

APPROACH CHANNEL-DISCHARGE OF 139,000 AND 75,000 CFS

FIGURE 7
HYD. REPORT 279



SPILLWAY CAPACITY CURVES
RADIAL GATE CONTROLLED



CONCRETE FINISHES
Surfaces covered by fill-Formed-F1, Uniform-F1
Exposed surfaces-Formed-F2, Uniform-F2
Spillway crest and floor-U3, highway bridge floor-U2, concrete gutter-U1

NOTE
Reinforcement not shown

THIS DRAWING SUPERSEDES DRAWING 328-D-274

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
MISSOURI BASIN PROJECT
FRENCHMAN-CAMBRIDGE UNIT-NEBRASKA
MEDICINE CREEK DAM
SPILLWAY
PLAN AND SECTIONS

DRAWN: R.F.L. SUBMITTED: *John A. Smith*
TRACED: P.M.F. RECOMMENDED: *John A. Smith*
CHECKED: *W. H. H. H.* APPROVED: *W. H. H. H.*
DENVER, COLORADO, JUNE 3, 1948

328-D-580

FIGURE 8
Hyd. Report No. 279

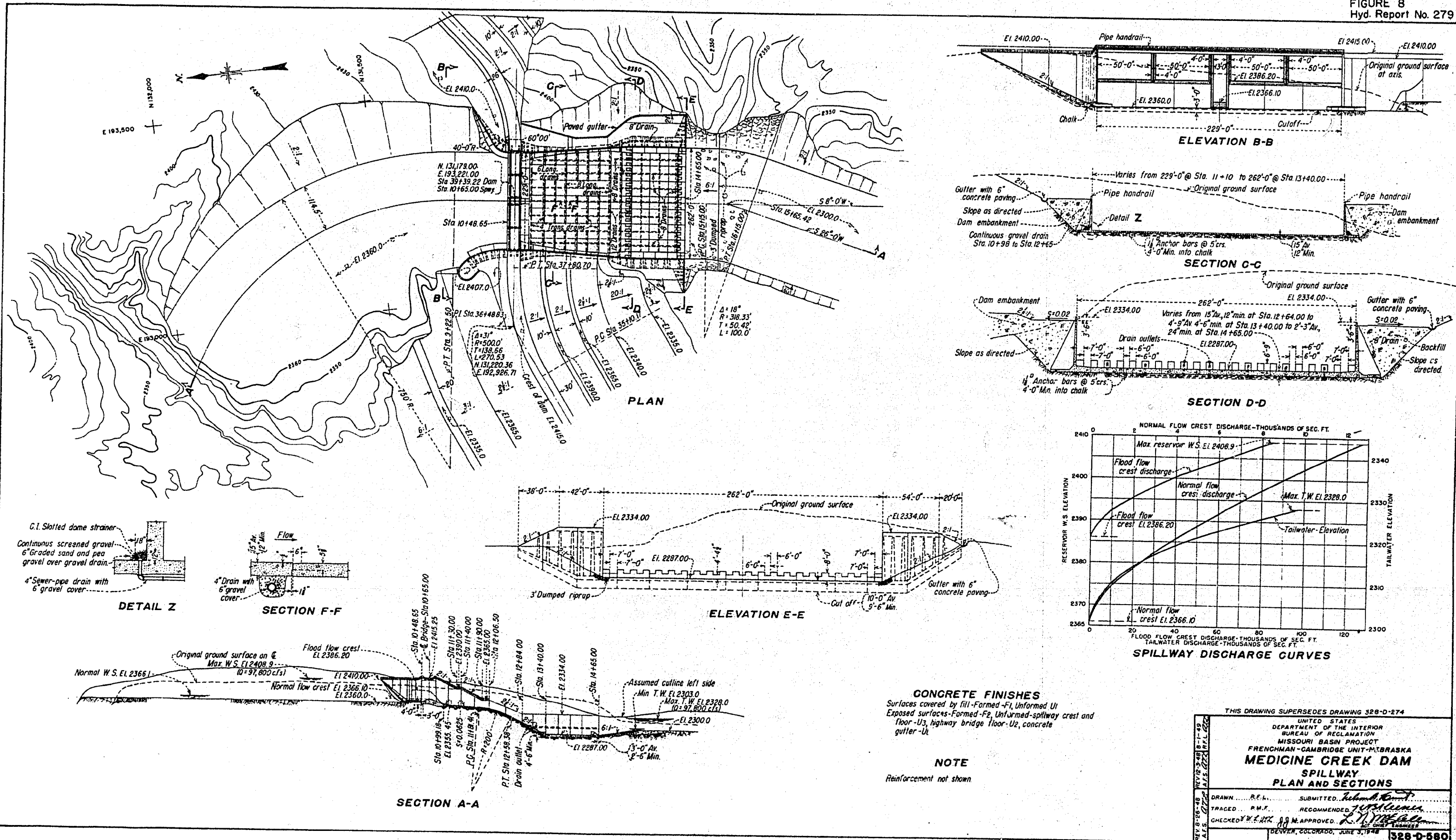
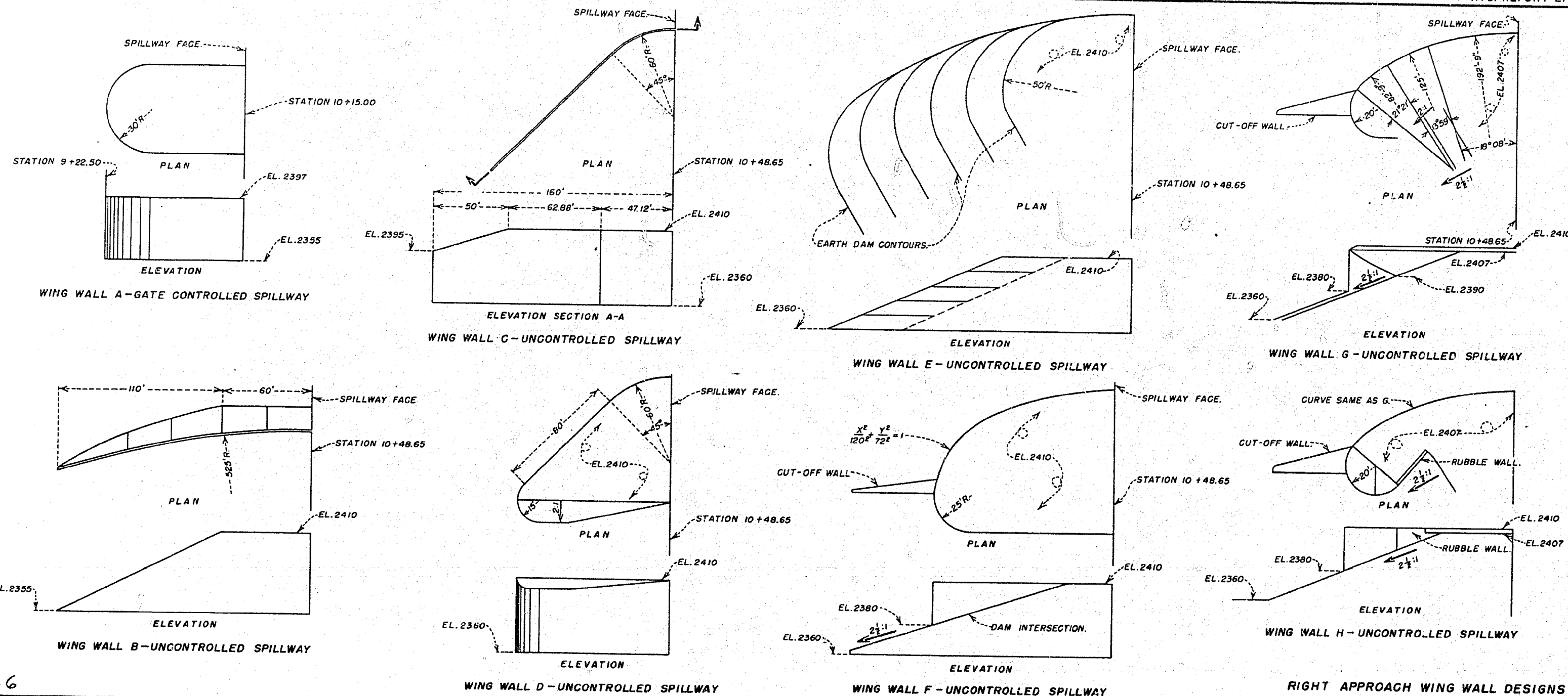
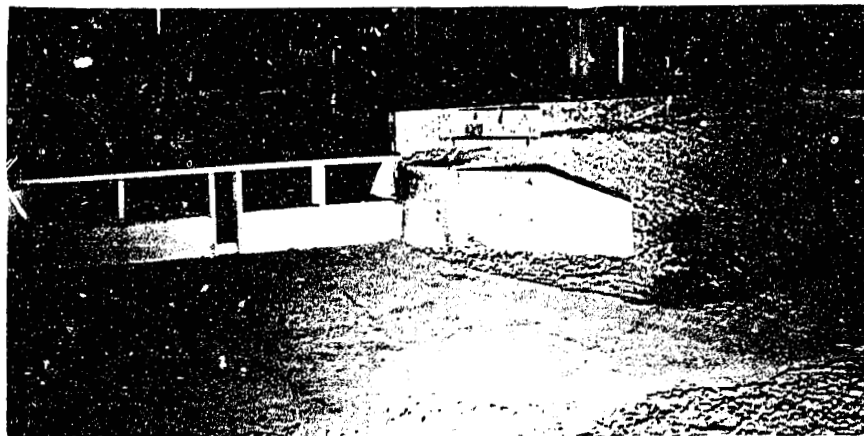
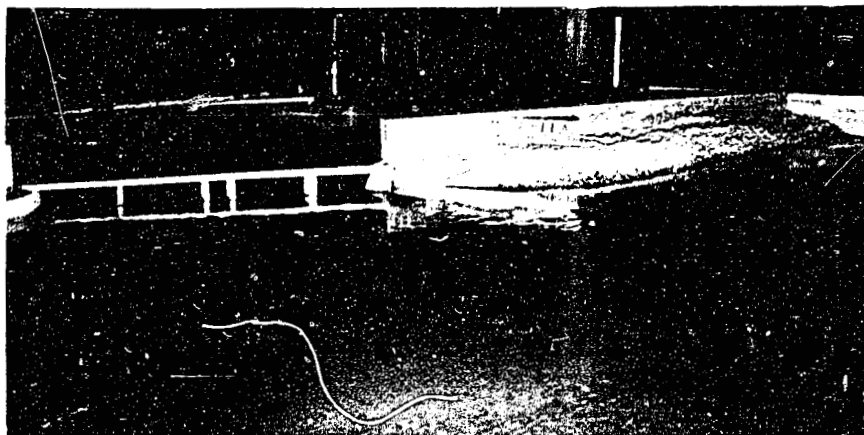


FIGURE 9
HYD. REPORT 279





A. Wing Wall C-Modified Spillway Design
Discharge 0 second-feet

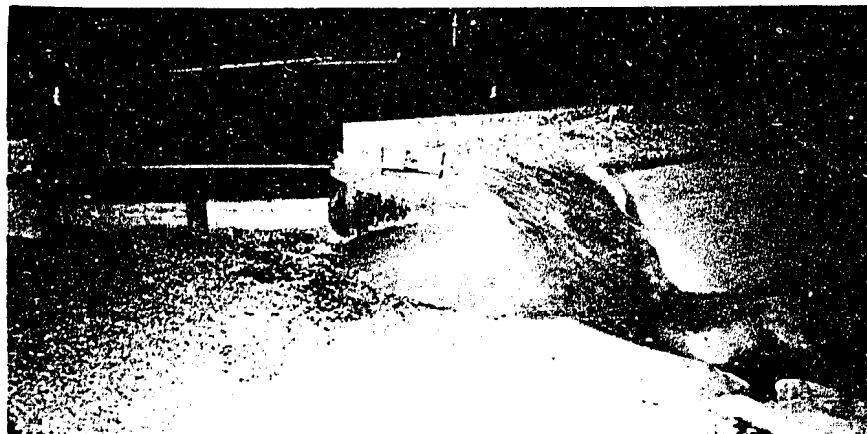


B. Wing Wall C-Modified Spillway Design
Discharge 60,000 second-feet

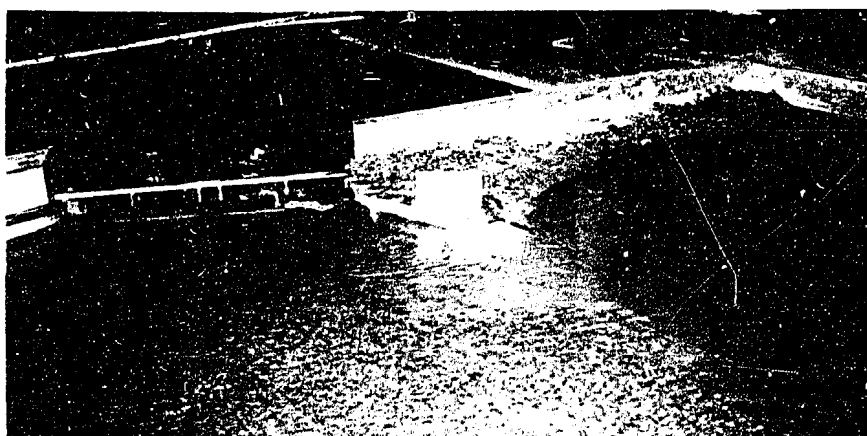


C. Wing Wall C-Modified Spillway Design
Discharge 97,800 second-feet

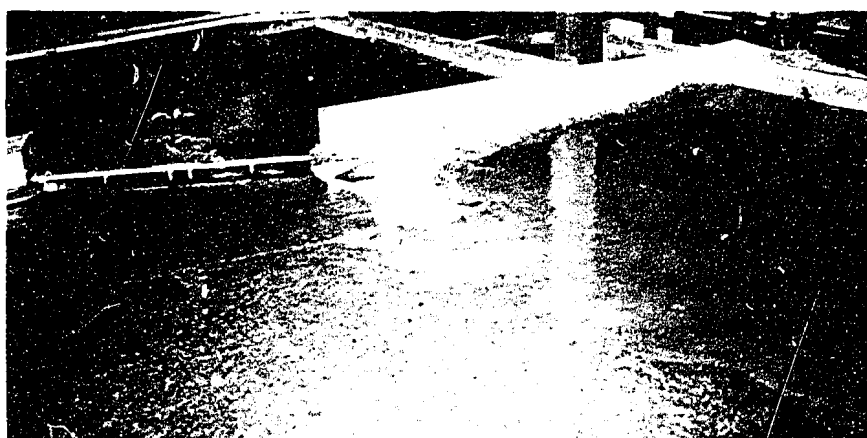
FLOW CONDITIONS FOR WING WALL C



A. Wing Wall D-Modified Spillway Design
Discharge 0 second-feet

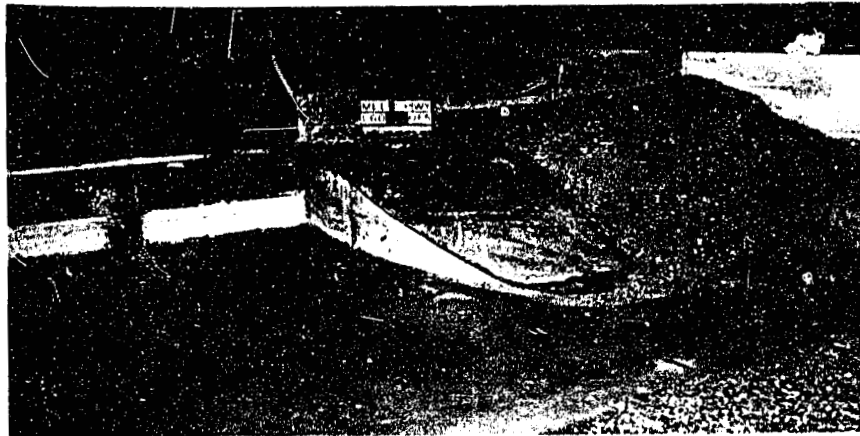


B. Wing Wall D-Modified Spillway Design
Discharge 60,000 second-feet

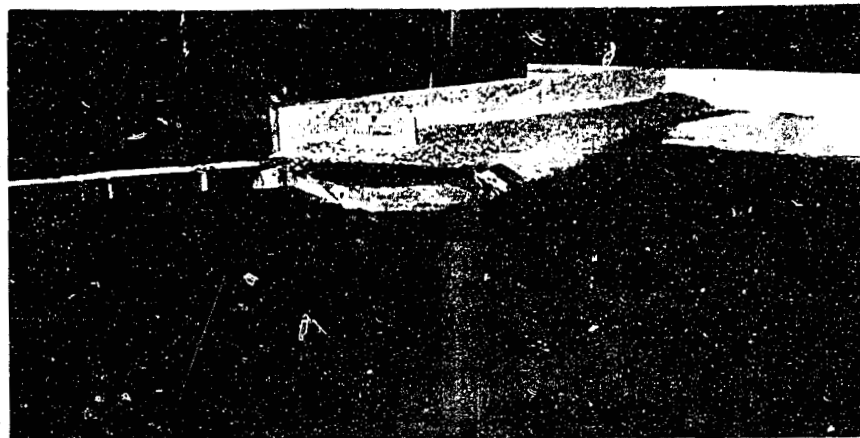


C. Wing Wall D-Modified Spillway Design
Discharge 97,800 second-feet

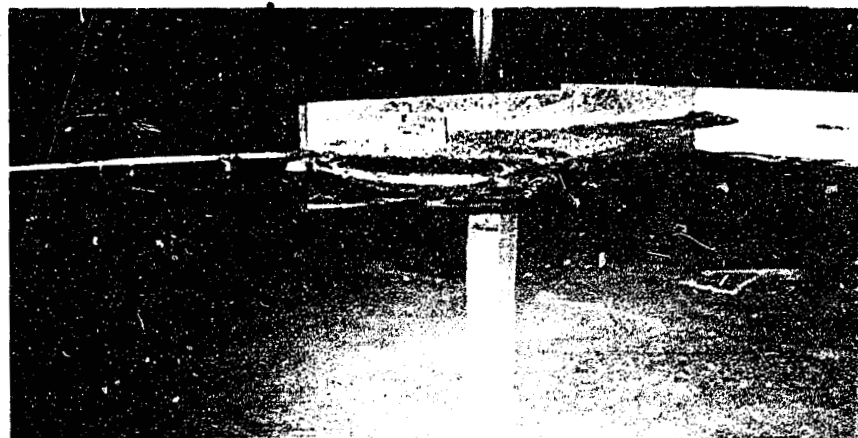
FLOW CONDITIONS FOR WING WALL D



A. Wing Wall E-Modified Spillway Design
Discharge 0 second-feet



B. Wing Wall E-Modified Spillway Design
Discharge 60,000 second-feet

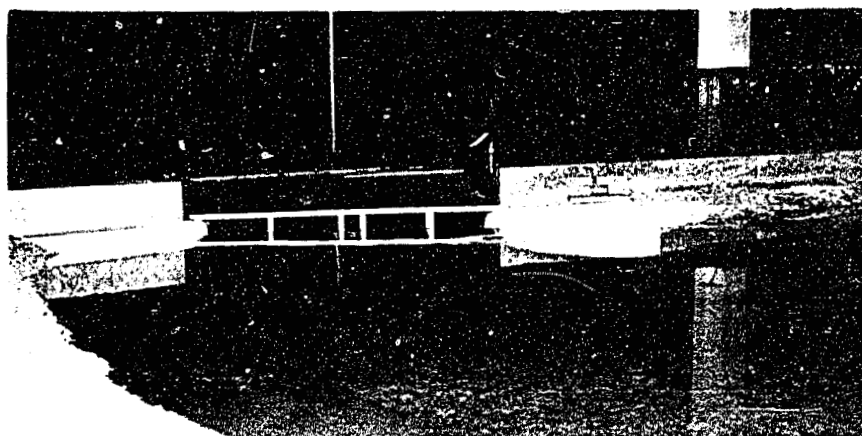


C. Wing Wall E-Modified Spillway Design
Discharge 97,800 second-feet

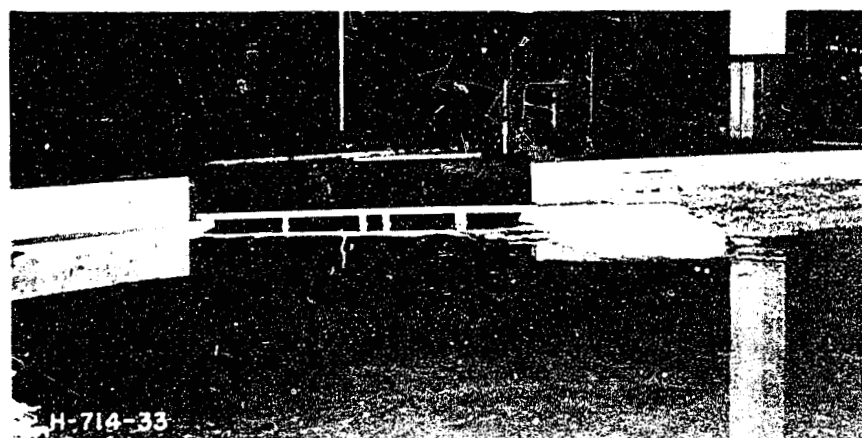
FLOW CONDITIONS FOR WING WALL E



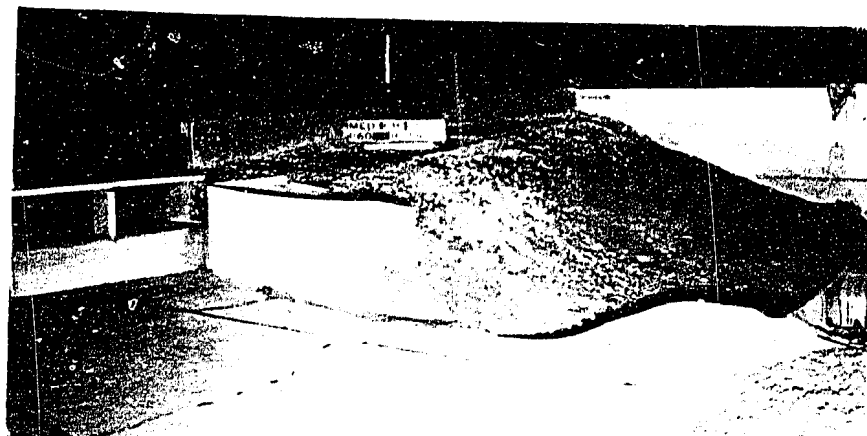
A. Wing Wall F-Modified Spillway Design
Discharge 0 second-feet



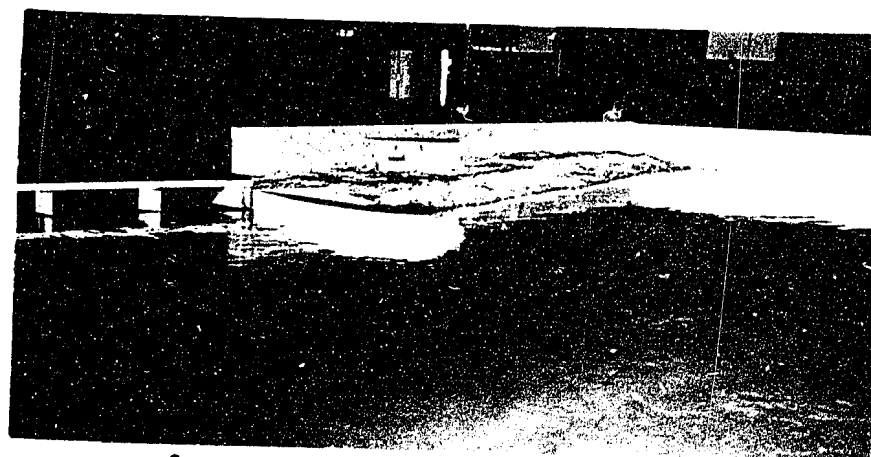
B. Wing Wall F-Modified Spillway Design
Discharge 60,000 second-feet



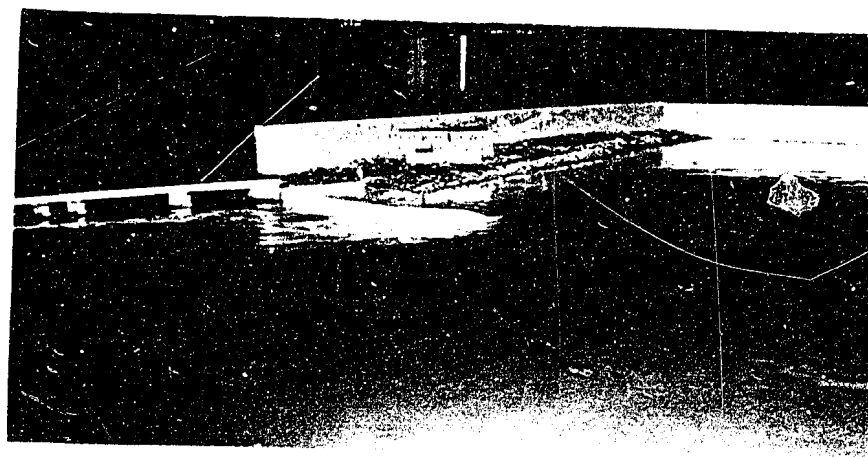
C. Wing Wall F-Modified Spillway Design
Discharge 97,800 second-feet
FLOW CONDITIONS FOR WING WALL F



A. Wing Wall G-Modified Spillway Design
Discharge 0 second-feet

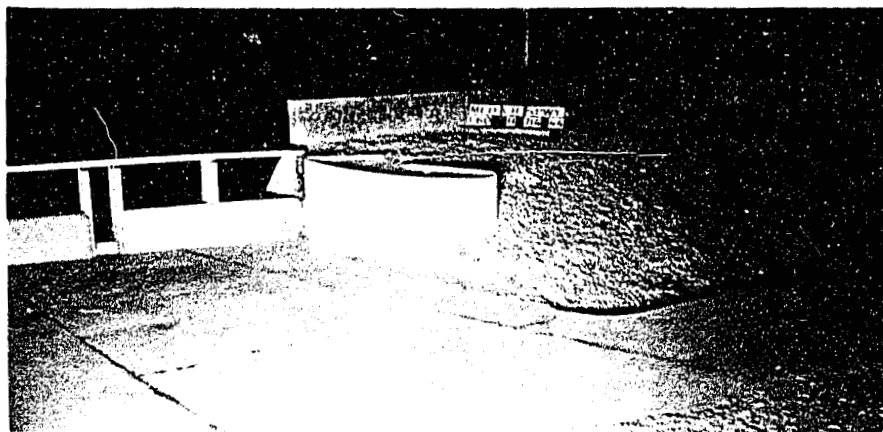


B. Wing Wall G-Modified Spillway Design
Discharge 60,000 second-feet

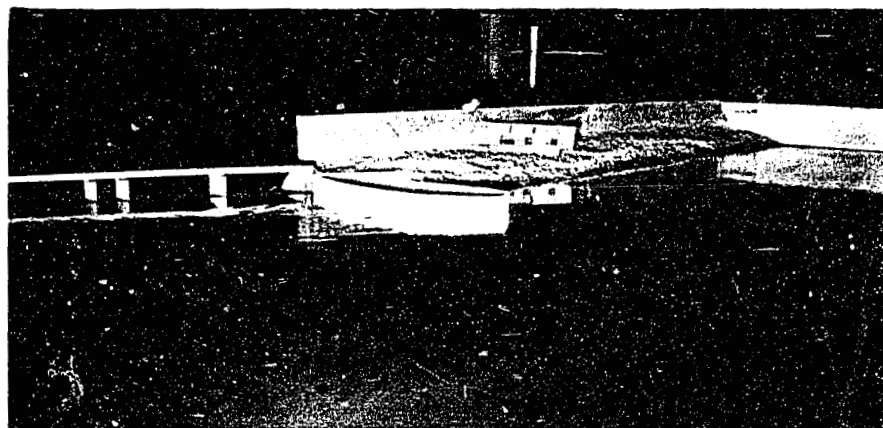


C. Wing Wall G-Modified Spillway Design
Discharge 97,800 second-feet

FLOW CONDITIONS FOR WING WALL G



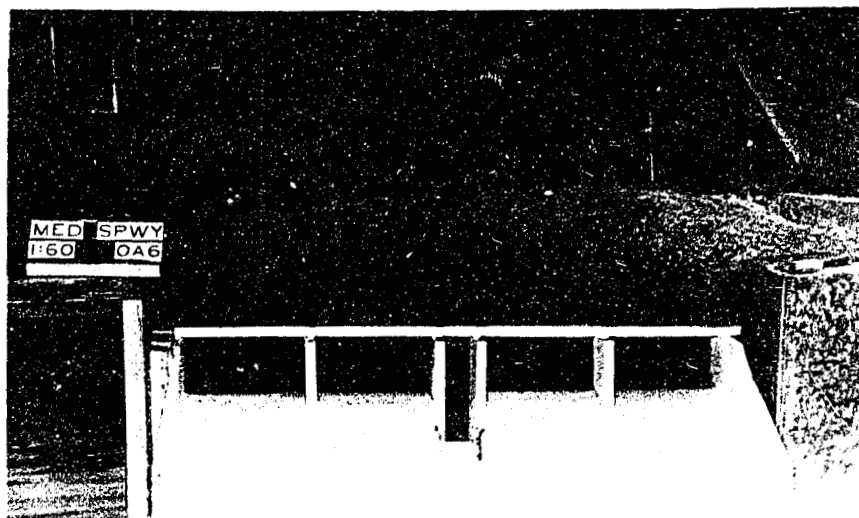
A. Wing Wall H-Modified Spillway Design
Discharge 0 second-feet



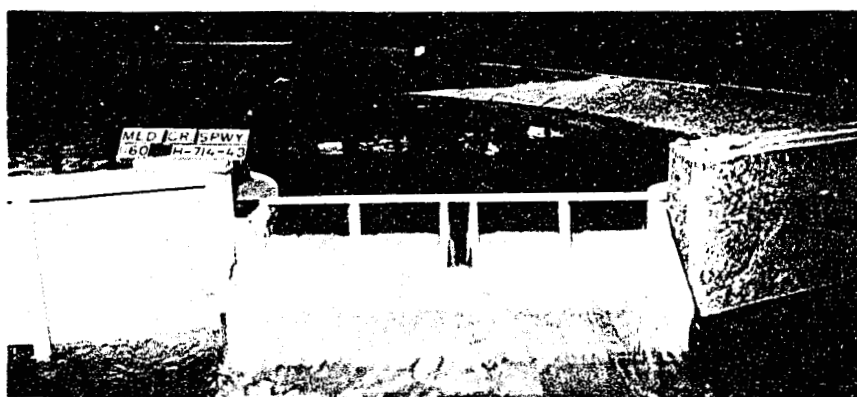
B. Wing Wall H-Modified Spillway Design
Discharge 60,000 second-feet



C. Wing Wall H-Modified Spillway Design
Discharge 97,800 second-feet
FLOW CONDITIONS FOR WING WALL H

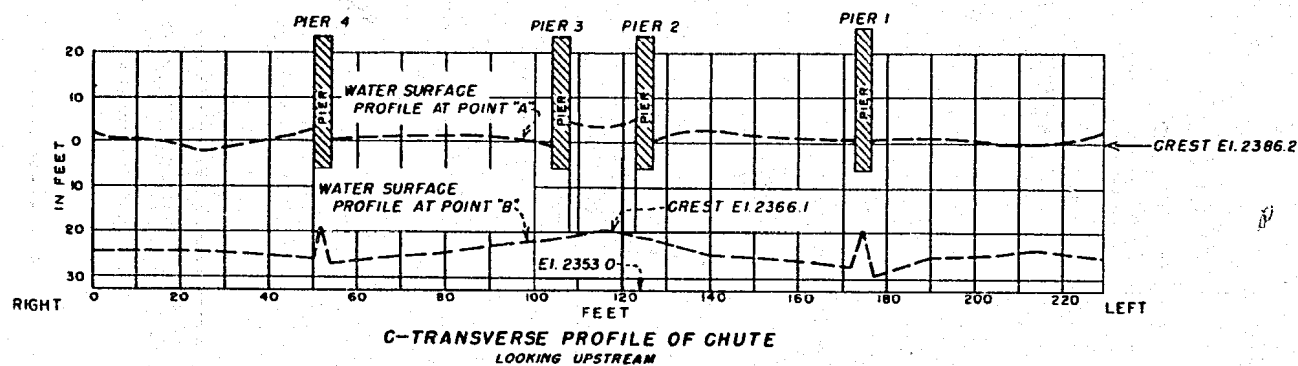
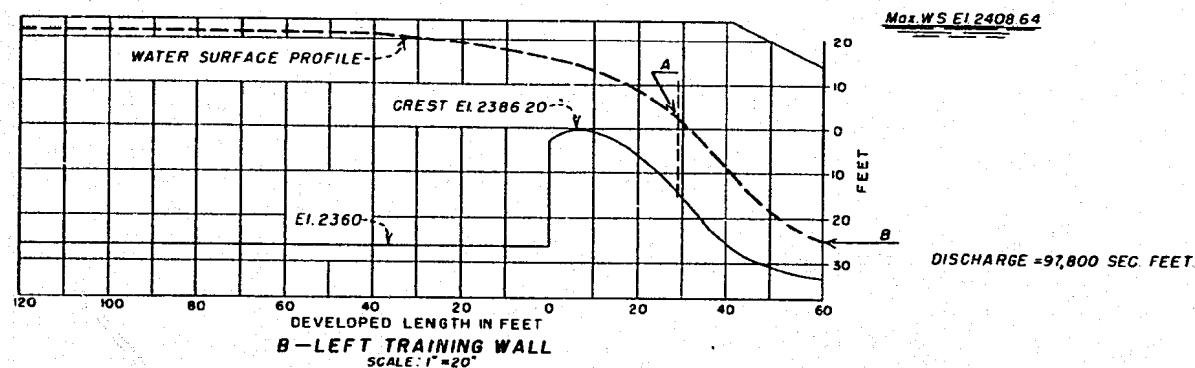
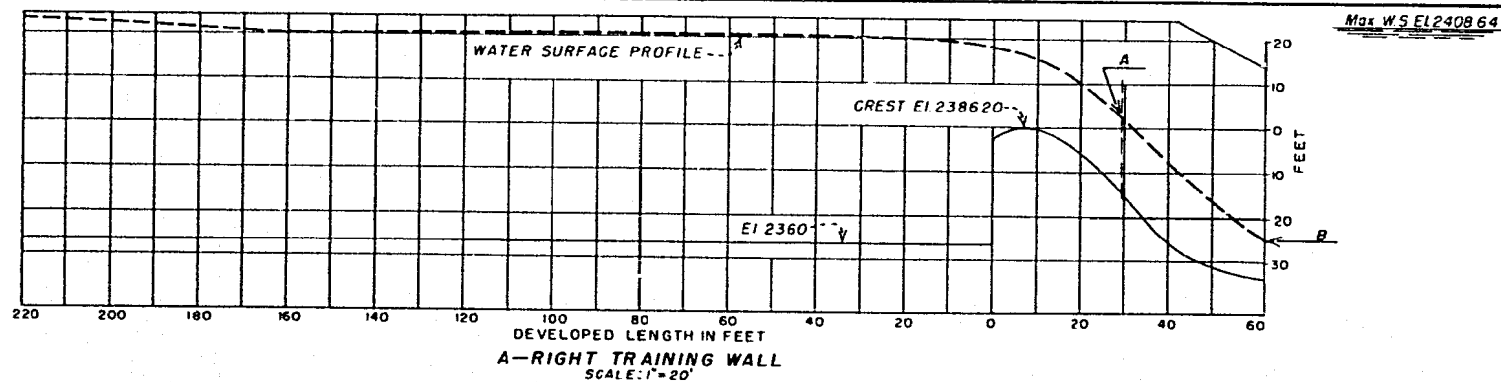


A. Spillway Crests Recommended Design
Discharge 0 second-feet

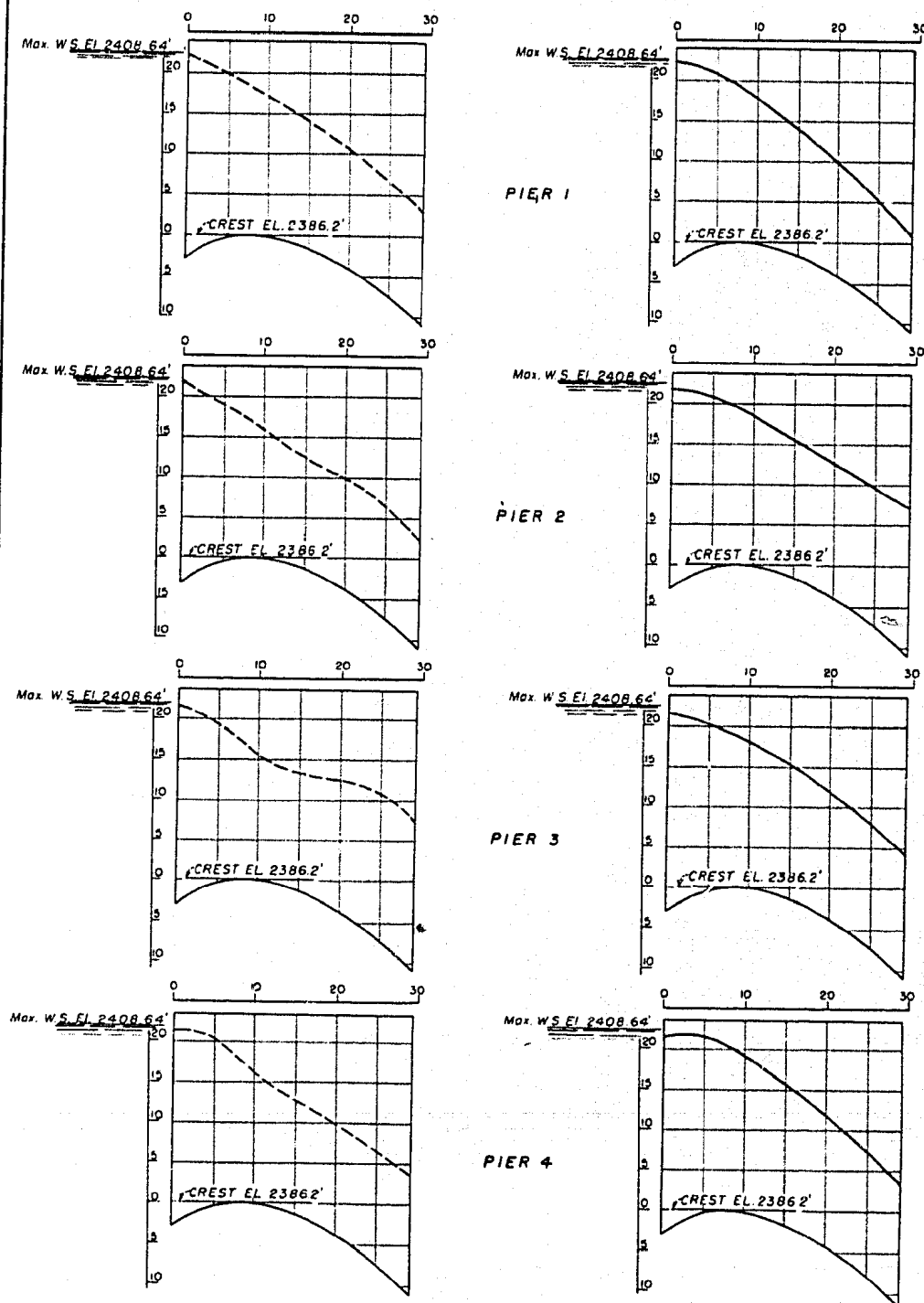


B. Spillway Crests Recommended Design
Discharge 97,800 second-feet

SPILLWAY CREST RECOMMENDED DESIGN



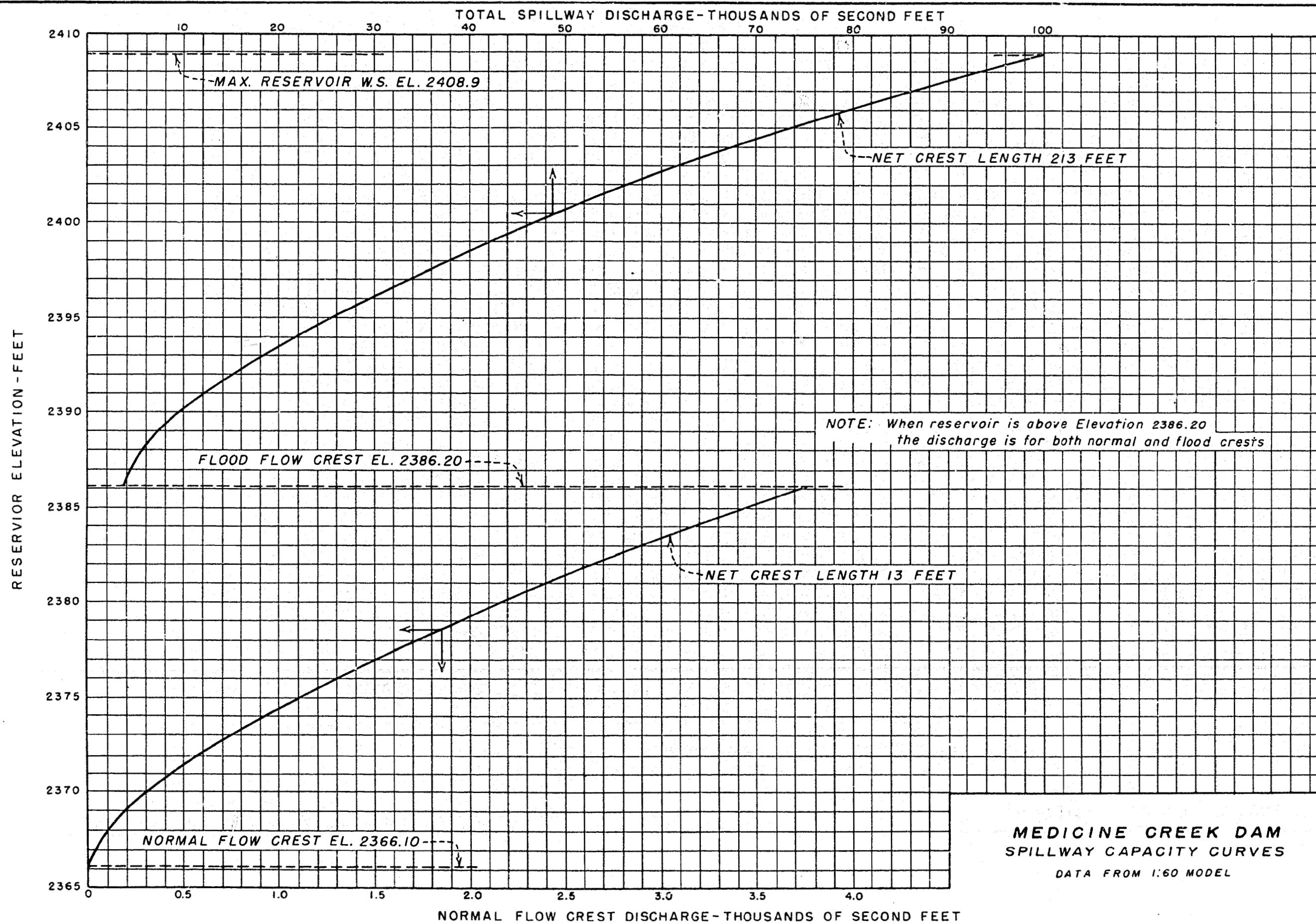
WATER SURFACE PROFILES--RECOMMENDED DESIGN
WINGWALL DESIGN H



NOTE
PIERS ARE NUMBERED FROM LEFT TO
RIGHT LOOKING DOWNSTREAM

WATER SURFACE PROFILE ON PIERS
WINGWALL DESIGN H

FIGURE 19
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MEDICINE CREEK DAM
SPILLWAY CAPACITY CURVES
DATA FROM 1:60 MODEL